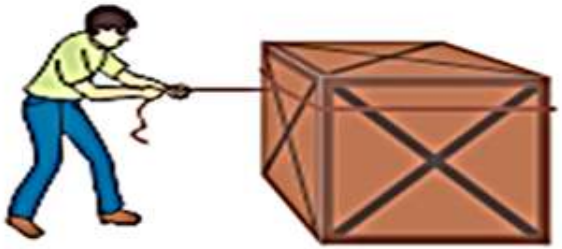
FORCE



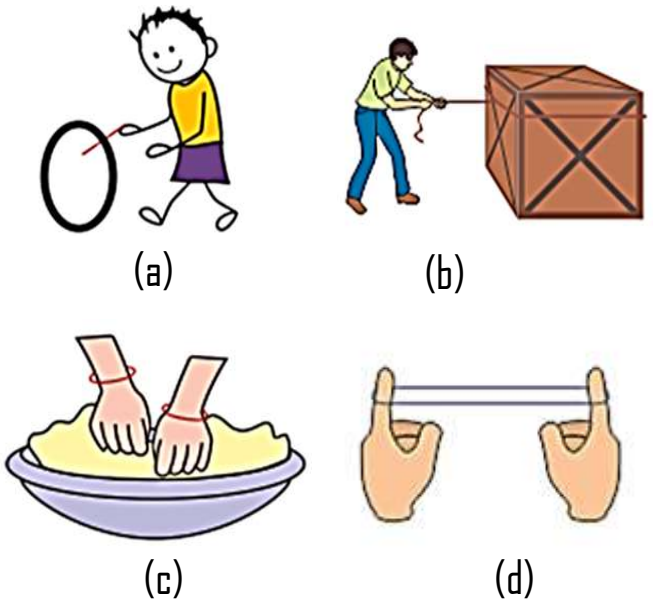
►►FORCE◄◄

Forces appear when two objects interact with each other. Whenever there is an interaction between two objects, there is a force upon each of the objects. When the interaction ceases, the two objects no longer experience the force.

Force has both magnitude and direction,making it a vector quantity. It is measured using the standard unit known as the **Newton** (N), and represented by the symbol F.

Efffects of force

- It can change the state or motion of the body
  - force change the state of motion of a tyre makes it to move faster (picture 1-a)
  - Box at rest moves due to force (picture 1-b)
- It can change the size or shape of the body
  - Force applied by hand on the dough change its shape (picture 1-c)
  - Force changes the size of a rubber band (picture 1-d)



picture 1

(Picture 2)
Tennis champion Rafael Nadal strikes the ball with his racket, applying a force and directing the ball into the open part of the court.

We can hit the ball at different speeds and direct it into different parts of the opponent's court. This means that we can control the magnitude of the applied force and also its direction, so force is a vector quantity, just like velocity and acceleration.

One force can act on only one object. To be absolutely precise the description of a force should include:

- its direction
- its magnitude
- the object on which it acts for the part of a large object
- the object that exerts the force
- the nature of the force

A description of the force shown in the picture 3 would thus be 'a 50 N push at 45° to the horizontal acting on the football from the boot'.

picture 3

►POINT FORCE◄

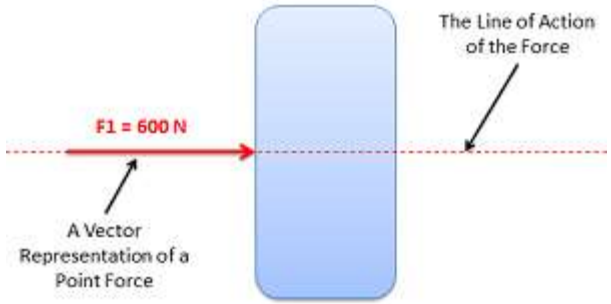
(a) (b)

picture 4

Force acting at a point is called **point force**. It acts on a very small area, compared to total surface area. It can be represented as a single vector. Here are some examples of point force in everyday life (picture 4-a, picture 4-b).

picture 5

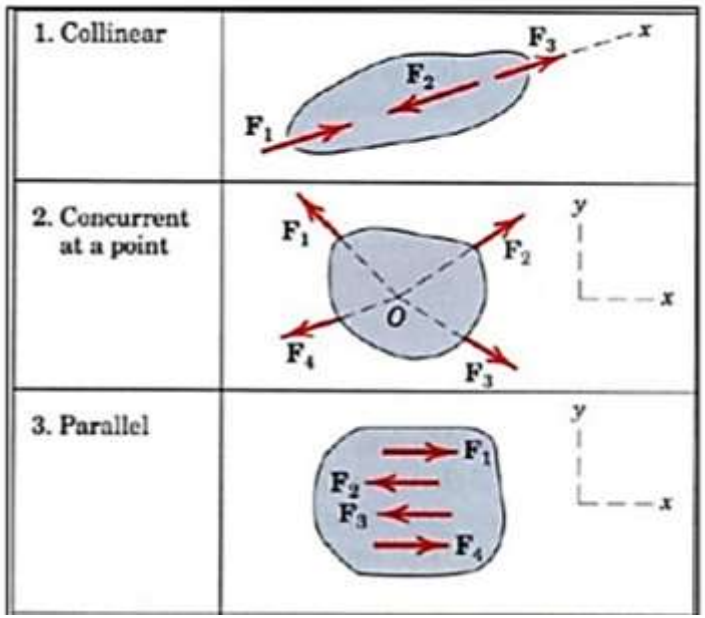
Point force is represented using arrow in a picture 5.
Size of the arrow is reflective of the magnitude of the point force. Direction of the arrow revels the direction that the point force is acting and point of application is point where the force is applied. In addition to the magnitude, direction, and point of application of the force, another important term to understand is the line of action of a point force (picture 6).
The line of action of a point force is the line along which the force acts.



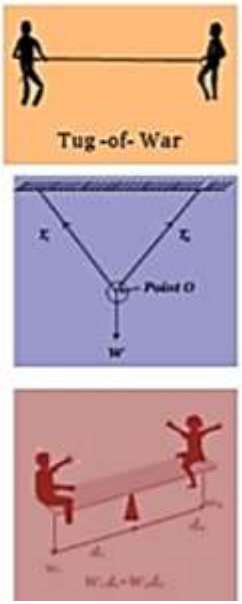
picture 6

►SYSTEM OF FORCES◄

When two or more forces act on body, they are called to form a **system of forces**.



picture 7



- **Collinear force system** (picture 7-1)
  A force system wherein forces act along a line is known as collinear force system. These forces may act in same direction or opposite directions.
- **Concurrent force system** (picture 7-2)
  A concurrent force system contains forces whose lines of action meet at some one point
- **Parallel force system** (picture 7-3)
  A parallel force system contains forces whose lines of action are parallel to each other

♦ Resultant force ♦

The **resultant force** ($\vec{R}$) is the vector sum of all forces exerted on a body or it is single force that has the same effect as all of the force acting on the object.

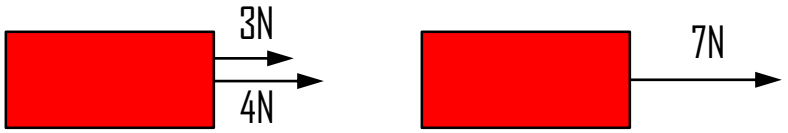
$$\vec{R} = \vec{F}_1 + \vec{F}_2 + \cdots + \vec{F}_n$$

According to the above equation, if an object is subject to no forces, then the resultant force is **zero**, and if an object is subject to only one force, then the resultant force is **equal to that force**.

♦ Resultant of parallel forces

▪ Forces in same direction

- Let's start with the simple case in which an object is subject to two forces that act in the same direction:



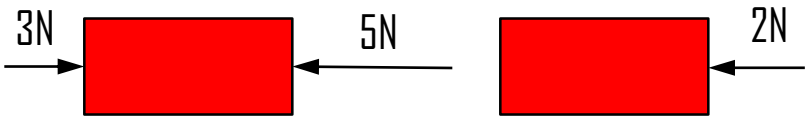
Picture 9: The resultant force is in the same direction as the two forces, and has the magnitude equal to the sum of the two magnitudes.

▪ Forces in different direction

- Let's start with the simple case in which an object is subject to two forces that act in the opposite direction:

Picture 10: The resultant force will be zero because two opposite forces cancel each other out.

- On the other hand, if the two forces are not equal in magnitude:

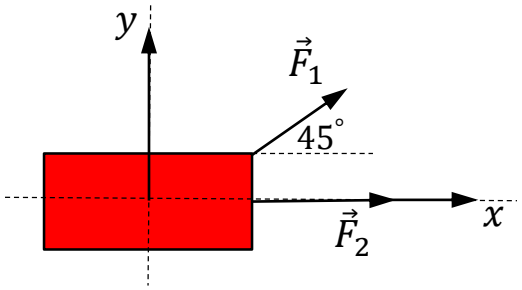


Picture 11: The resultant force will be in the same direction as the force with the larger magnitude, and have the magnitude equal to the difference between the magnitudes of the two forces.

Example 1

A block is pulled by two forces of 15 N and 25 N to the left, and by three forces of 10 N, 20 N, 30 N to the right.
Find the magnitude and direction of the resultant force.

♦ Resultant of concurrent forces

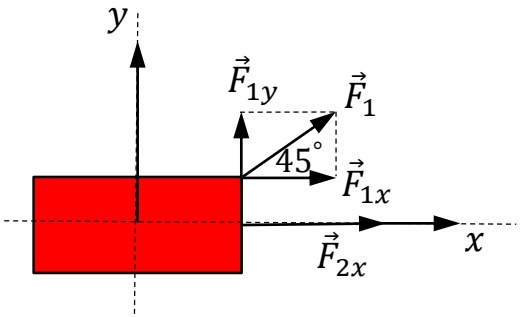


picture 12

Let's assume that we have a block subject to two forces, F_1 and F_2. F_1 has magnitude 50 N and is applied at a 45° angle, whereas F_2 has magnitude 60 N and is applied horizontally, as shown in picture 12

Since one of the two forces is horizontal, for convenience, we choose the x-axis horizontal, and the y-axis vertical, and we place the origin at the center of our block:

The next step is to determine the x and y components of all the forces that act on the block (picture 13):



picture 13

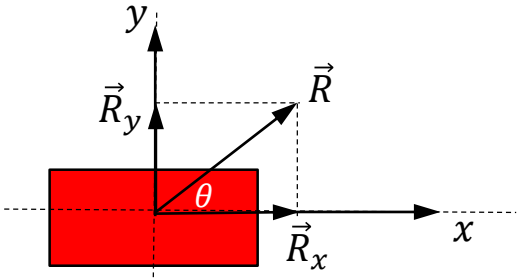
If we sum all the x components, we will get the x component of the resultant force:

$$R_X = F_{1x} + F_{2x}$$

If we sum all the y components, we will get the y component of the resultant force:

$$R_y = F_{1y} + F_{2y} = F_{1y}\ (F_{2y} = 0)$$

At this point, we know the x and y components of R, which we can use to find the magnitude and direction of R (picture 14):



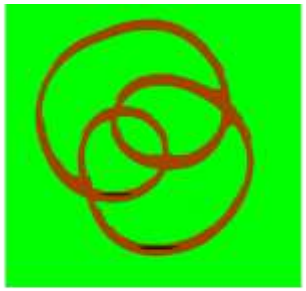
picture 14

The magnitude of R can be calculated by applying Pythagoras' Theorem:

$$R = \sqrt{R_x^2 + R_y^2}$$

►ELASTIC AND PLASTIC DEFORMATIONS◄

Two most common types of deformation are **elastic** and **plastic deformations**.



Rubber band Soccer ball

Picture 15

When the applied force is not sufficient to cause a permanent change, the object regains its original shape once the force is removed. This is known as **elastic deformation**. It means that the deformation exhibits an elastic behaviour. Here are some examples of elastic deformation in everyday life (picture 15).

Sometimes, a force being applied on a body may be massive, This may cause a permanent change in the shape of a body. This type of deformation is referred to as **plastic deformation**. Here are some examples of plastic deformation in everyday life (picture 16).

Clay Dough or bread

picture 16